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Effects of soil covers on late-fall seedings of four tall fescue varieties

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Soil covers promote seed germination and plant growth at suboptimum temperatures by conserving heat near the soil surface. This conservation of heat results in a higher soil surface temperature than in uncovered soils. The result is succulent seedlings that may be more susceptible to premature death during winter and reduced growth the following season. The objectives of this study were to evaluate the effectiveness of soil covers for promoting seed germination in the fall and to observe the effects of soils covers on plant growth and development. A field study was conducted using Clemfine, Mustang, Rebel and Rebel II varieties of tall fescue (*Festuca arundinacea* Schreb.) sown in mid-October in New Hampshire using a randomized block design. Half of each plot was covered with a spun-bonded polypropylene soil cover. The cover remained on the plots until the following June. It enhanced seedling emergence in the fall for all four varieties and subsequent regrowth during May for all varieties except Rebel. Very little extra growth was observed under the cover during April, when average ambient temperatures were about 6.2°C. Analysis of tissue sampled in June showed that the carbohydrate content was lower with the higher-yielding varieties. Higher-yielding varieties that had been covered showed lower concentrations of fructans in leaves, but the levels were not sufficient to affect summer growth. No differences in carbohydrate concentrations between varieties were found. Test results show that the use of soil covers promoted seed germination of late fall seedings and improved grass growth through the following August.

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PREFACE

This report was prepared by Antonio J. Palazzo, Research Agronomist, Geochemical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory. This research was funded by the Natural and Cultural Resources Division of the U.S. Army Engineering and Housing Support Center, Ft. Belvoir, Virginia, under the direction of Donald Bandel.

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Effects of Soil Covers on Late-Fall Seedings of Four Tall Fescue Varieties

ANTONIO J. PALAZZO

INTRODUCTION

Soil covers may be beneficial for late-fall turfgrass seedings because they reduce heat loss immediately above the seedbed. General observations have shown that plants germinate and grow more rapidly when a cover keeps the soil surface temperatures higher than the ambient air temperature.

In some situations, soil covers are used in the late fall to conserve heat, thereby lengthening the growing season and permitting plants to germinate before winter. This technique may help prevent injury to seedlings when the seeds are sown late in the season. When plants are able to grow at temperatures 2°C lower than their present limit, they could increase their growing season by two weeks (Young 1988). In a review on low-temperature stress in field and forage crops, Andrews (1987) reported that lower-than-optimum temperatures in the growing season may reduce germination. Miedema (1982) reported that lower-than-optimum temperatures reduce the growth of roots, which are then less effective during later stress periods, while nongerminating or slowly germinating seeds may be damaged by fungal or bacterial pathogens.

Late seedings under a cover, however, produce succulent plants that may be more susceptible to cold injury because they do not go through the hardening-off process. Winter survival of plants partially depends on adequate energy reserves and carbohydrates. The amount of reserves present is related to the rates of photosynthesis, respiration and growth (Schmidt and Blaser 1967). Active shoot and root growth during the fall has been known to decrease the carbohydrate content of plants and prevent them from building up a carbohydrate reserve to carry them through the winter months. Carrol and Welton (1939) showed that late-fall applications of nitrogen reduced the cold tolerance of turfgrasses. Wilkinson and Duff (1972) showed that the cold resistance of Kentucky bluegrass in Rhode Island increased in the fall and early winter, peaked near the end of January, decreased slowly through February, and was lost rapidly in March and April. Early-fall fertilization, which probably promoted the growth rate, reduced the cold resistance in the fall. Duff (1974) and Duff and Beard (1974) noted that carbohydrate content of turfgrass plants was lowest when shoot growth was greatest.

There are generally four components of the carbohydrates in grasses. The reducing sugars are fructose and glucose, while the nonreducing sugar is primarily sucrose (Cooper et al. 1988, Okajima and Smith 1964, White 1973). The principal storage carbohydrates in cool-season grasses are fructose polymers of varying lengths, known as fructans. Cultural practices that promote the rapid growth of plants decrease the quantity of fructans (Okajima and Smith 1964, Younger and Nudge 1968).

During cold-hardening the growth rate and metabolic activity decrease but photosynthesis remains strong, which leads to a build-up of carbohydrates (Housley and Polluck 1985). Excess nonstructural carbohydrate may accumulate to greater than 50% of the dry weight of many field crops (Smith 1972). Housley and Polluck (1985), studying *Lolium temulentum* L., found that sucrose and fructans are stored in the vacuoles of leaves when there is greater supply than demand. Once stored, carbohydrates are sensitive to demands made by the plant and its growth environment and can therefore be depleted when the growth rate increases, as may take place below the soil covers used in this study. Andrews (1987), in a review of low-temperature stress in field and forage crops, reported that fructans accumulate in plants when the use of carbohydrates slows, because the fructan-synthesizing enzyme has a remarkably low optimum temperature.

The objective of this study is to evaluate the effects of soil covers on late-fall germination, winter survival and spring regrowth of four varieties of tall fescue. This information will provide a greater understanding of low-temperature effects on turfgrass seedlings and the use of soil covers to conserve soil heat and extend the fall seeding season.

MATERIALS AND METHODS

Seeds of Clemfine, Mustang, Rebel and Rebel II* tall fescue (*Festuca arundinacea* Schreb.) were sown on 15 October 1987 on a silty loam soil in Hanover, N.H. All grasses were seeded at a rate of 0.22 kg/m^2. The experimental design included three replications each of the four tall fescue varieties. Each plot was 2 m square. Prior to seeding, the soils were fertilized at a rate of 5 g/m^2 for each of nitrogen, phosphorus and potassium. After seeding, the soils were rolled, and half of each plot was covered with a spun-bonded polypropylene material call Typar, manufactured by the Reemay Company, Old Hickory, Tennessee.

Visible differences were noted, and the heights of germinated seedlings were measured on 16 November 1987 and 19 April, 5 May and 1 June 1988. Yields were taken on 8 June (immediately after the cover was removed) and 22 August 1988. Biomass was measured by clipping the plants 5 cm above the soil surface over 1 m^2; tissue collected for the June harvest was dried at 100°C for one hour and at 70°C for 48 hours to constant weight and then weighed. A 20-mg subsample of the dried tissue was collected, ground through a 40-mesh screen and prepared for carbohydrate analysis. The leaf tissue was analyzed for the carbohydrates glucose, fructose, sucrose and fructans using the method reported by Westhafer et al. (1982). Duplicate subsamples were taken and analyzed, and the mean of each pair of analytes was recorded. Tissue from the second harvest was dried for 48 hours at 70°C and weighed to obtain yields.

All results from the plant yield and carbohydrate concentration data were subjected to an analysis of variance, and the means were separated using the Duncan's Multiple Range Test (Little and Hills 1978).

RESULTS AND DISCUSSION

The tall fescues in this study were sown on 15 October, which is considered late fall in New Hampshire, and the plants were evaluated one month after seeding. The soil covers improved fall germination of all tall fescue varieties. The heights of the grass seedlings under the covers had a mean of 3 cm on 16 November (Table 1). Where the cover was not used, only a small number of seeds had germinated, and the mean height was less than 1 cm. The mean ambient temperature from 15 October to 30 October was 8°C; for November it was 4°C. Grasses below the cover were more succulent and had a darker green color than those without the cover. There were no major differences between varieties.

The plants were next rated on 19 April, before the beginning of the normal growing season at Hanover (Table 1). All varieties of tall fescue growing under the cover were similar and were darker green than those without the cover. There were only minor increases in plant heights between the April and May ratings, so the covers did not promote leaf growth until after 5 May. The mean monthly temperature in April was about 6°C, which was apparently too low to improve growing conditions below the covers. There were also no relevant differences between varieties during the 5 May rating.

At the 1 June rating, grasses under the cover had developed more rapidly than earlier in the year (Table 1). The covered plants were nearly twice as tall and were darker green than those without the cover. In May the mean ambient temperature above the covers had increased to 14°C.

Tissue from the June harvest was analyzed for reducing sugars (fructose and glucose), nonreducing sugars (sucrose) and storage carbohydrates (fructans) to evaluate the effect of the covers on changes in carbohydrate concentrations in plants. This harvest was taken after a period of rapid plant growth. All of the correlations between yields and carbohydrate concentrations were negative (Table 2). This was also observed by Duff and Beard (1974) for bentgrasses, Cooper et al. (1988) for annual bluegrass, Okajima and Smith (1964) for tall fescue and Younger and Nudge (1968) for Kentucky bluegrasses. The negative correlations between

Table 1. Plant heights of four tall fescue varieties.

Variety	Soil cover	Heights (cm) 11/16/87	4/19/88	5/5/88	6/1/88
Rebel II	Yes	3	3	3	12
	No	<1	<1	<1	8
Rebel	Yes	3	2	3	9
	No	<1	<1	<1	5
Clemfine	Yes	3	2	3	10
	No	<1	<1	<1	5
Mustang	Yes	3	3	3	11
	No	<1	<1	2	6

* According to the Loft's Seed Co., there is no special genetic relationship between Rebel and Rebel II.

Table 2. Correlations (r) of various carbohydrate forms and plant yields.

	Fructose	*Glucose*	*Sucrose*	*Fructan*	*Total carbohydrate*	*Yield*
Fructose	1.00					
Glucose	0.84	1.00				
Sucrose	0.22	−0.13	1.00			
Fructan	0.82	0.45	0.51	1.00		
Total carbohydrate	0.96	0.72	0.42	0.93	1.00	
Yield	−0.55	−0.45	−0.03	−0.38	−0.47	1.00

carbohydrate concentrations and yields found in this study were similar for three of the carbohydrates and for the total amount of carbohydrate. The mean sucrose concentrations in the plants only ranged from 0.0 to 1.47% of the sample and therefore were too low to allow a meaningful test on differences.

High correlations were found between the various carbohydrates and the total amount in the plants (Table 2). This was because fructans made up between 43 and 50% of the carbohydrates in the plant. This was especially true for fructose (r = 0.96) and fructans (r = 0.93), which were similarly affected by changes in carbohydrate concentrations.

Fructose and glucose had a correlation of 0.84. These are similar reducing sugars, and they changed in similar amounts as conditions or varieties changed. Fructose was also highly correlated with fructans (0.82), which is understandable, since the latter is primarily a grouping of fructose polymers. The lowest correlations were those related to sucrose, probably because of the low concentration of this carbohydrate in these plants.

Table 3. Plant yields for each variety at the two harvests.

Variety	*Soil cover*	*Yield (gm/plot)* 6/8	8/24
Rebel II	Yes	49.5 a*	64.4 ab
	No	25.5 c	51.3 abc
Rebel	Yes	15.5 d	35.6 c
	No	30.2 c	43.0 bc
Clemfine	Yes	47.2 a	74.3 a
	No	24.3 c	57.2 abc
Mustang	Yes	36.7 b	45.9 bc
	No	8.7 d	45.0 bc

* Means followed by the same letter were not significantly different for each harvest according to the Duncan's Multiple Range Test at the 0.05 level of probability.

Plant yields were measured immediately after the covers were removed on 8 June. In all cases except Rebel, the grasses grown beneath the covers produced greater yields than those without the cover (Table 3). The greatest increase in growth was for Mustang. The growth of Rebel II and Clemfine increased by about 100% with the soil cover. Rebel was the only variety to produce greater yields without the cover than with the cover. The reason for this is not known. The yield differences were observed in all three replications. With a soil cover, Rebel was the lowest yielder; without the cover, Mustang was the lowest yielder.

Yields were again recorded in August (Table 3). Although the covers had been removed for most of the growing season, the effects of the cover were still evident. However, differences in yields were not as great as at the 8 June harvest. Rebel still produced higher yields on plots that had not been covered. The yields of Rebel II and Clemfine were 26 and 30% in the plots that had been covered, while the yield of Mustang was nearly the same in both plots.

The amount of carbohydrates in the plants was greater when the soil cover was not used (Table 4) and was related to the lower yields (Table 3). Fructans were the dominant form of carbohydrates in the plant leaves. Duff (1974) found that the greatest concentrations of carbohydrates in Kentucky bluegrass plants were of the long-chain variety, which is primarily fructans. Cooper et al. (1988), working with annual bluegrass, and Okajima and Smith (1964), working with tall fescue, found that fructans were still the predominant form of carbohydrates. Total carbohydrate concentrations found here and shown in Table 4 agree with those reported by Zarrough and Nelson (1980) for tall fescue.

Differences in carbohydrate concentrations were noted between varieties of tall fescues (Table 4). Rebel, the variety that had greater yields, did have more of the reducing sugars in plants that were covered by the blankets. This effect appears to be largely due to this variety's lower growth rate or to other varietal differences. All other varieties had

Table 4. Mean carbohydrate concentrations in tall fescue leaves for the 8 June harvest.

Variety	*Soil cover*	*Concentration (% of sample)* Fructose	Glucose	Sucrose	Fructan	Total
Rebel II	Yes	3.0	3.1	0.3	5.1	11.5
	No	4.0	3.5	0.6	6.5	14.6
Rebel	Yes	2.8	2.5	0.3	4.1	9.7
	No	2.7	1.9	1.1	5.6	11.3
Clemfine	Yes	2.0	1.3	0.1	3.3	6.7
	No	3.3	2.3	0.4	7.2	13.2
Mustang	Yes	2.3	2.3	0.0	3.3	8.0
	No	3.5	3.6	0.0	5.4	12.5

Table 5. Percent reductions in carbohydrate forms of tall fescue varieties when covered with a soil cover.

Variety	*Reduction in carbohydrate (%)* Fructose	Glucose	Sucrose	Fructan	Total
Rebel II	25	11	NA*	22	21
Rebel	+14	+32	NA	27	14
Clemfine	34	36	NA	39	36
Mustang	39	43	NA	54	49

*NA—Numbers too small to be meaningful.

lower concentrations of the various types of carbohydrates when they were covered with the blanket and therefore producing more biomass.

Greater reductions of total carbohydrates were observed for Rebel II, Mustang and Clemfine than for Rebel (Table 5). This supports the results of Duff and Beard (1974), who reported decreases in reserve carbohydrates during increased growth. Davidson (1968), Schmidt and Blaser (1967), Watschke et al. (1970) and Younger and Nudge (1976) have found negative relationships between temperature and total carbohydrates of various turf species. The carbohydrate levels of Rebel were least affected by the cover; this is probably directly related to its lack of aggressive growth in this situation. Interestingly, fructose and glucose levels of Rebel were 14 and 32% higher, respectively, in plants under the cover; this may be related to the lower yields recorded in that environment.

CONCLUSIONS

This study shows that soil covers can extend the fall planting season for tall fescues in cold climates such as New Hampshire. Seeds germinated more rapidly in the fall, the seedlings had good color in the early spring, and additional growth was observed in May. The cover had only a small effect on growth in early spring, however. Although the carbohydrates of the tall fescue varieties were reduced under the covers at the June sampling, they apparently were still at a sufficient level to maintain growth during the summer.

Rebel was the only variety that did not produce greater yields under the cover. The reason for this result is not known. Since plant heights were greater beneath the cover, the lower yields seem to be directly related to a lower germination rate and therefore a lower stand density below the cover. From the results of this one-year study, Rebel should be considered for late seedings when no soil covers are used.

LITERATURE CITED

Andrews, C. J. (1987) Low temperature stress in field and forage crop production—An overview. *Canadian Journal of Plant Sciences*, **67**: 1121–1133.

Carrol, J. C. and F. A. Welton (1939) Effects of heavy and late applications of nitrogenous fertilizer on the cold resistance of Kentucky bluegrass. *Plant Physiology*, **14**: 297–308.

Cooper, R. J., J. R. Street, P. R. Henderlong and A. J. Koski (1988) An analysis of the carbohydrate status of melfluidide-treated annual bluegrass. *Agronomy Journal*, **80**: 410–414.

Davidson, R. L. (1968) Effects of edaphic factors on the soluble carbohydrate content of roots of *Lolium perenne* L. and *Trifolium repens* L. *Annals of Botany*, **33**: 579–589.

Duff, D. T. (1974) Influence of fall nitrogenous fertilization on the carbohydrates of Kentucky bluegrass. *Proceedings of the Second International Turfgrass Research Conference* (E.C. Roberts, Ed.). American Society of Agronomy, Madison, Wisconsin, p. 112–119.

Duff, D. T. and J. B. Beard (1974) Supraoptimal temperature effects upon *Agrostis palustris*. Part II. Influence on carbohydrate level, photosynthetic rate, and respiration rate. *Physiologia Plantarum*, **32**: 18–22.

Housley, T. L. and C. J. Polluck (1985) Photosyn-

thesis and carbohydrate metabolism in detached leaves of *Lolium temulentum* L. *New Phytology*, **99**: 499–507.

Little, T.M. and F.J. Hills (1978) *Agricultural Experimentation: Design and Analysis*. New York: John Wiley and Sons.

Miedema, P. (1982)The effects of low temperature on *Zea mays*. *Advances in Agronomy*, **35**: 93–128.

Okajima, H. and D. Smith (1964) Available carbohydrate fractions in the stem bases and seed of timothy and smooth bromegrass, and several other northern grasses. *Crop Science*, **4**: 317–320.

Schmidt, R. E. and R. E. Blaser (1967) Effect of temperature, light and nitrogen on the growth and metabolism of 'Cohansey' bentgrass (*Agrostis palustris* Huds.). *Crop Science*, **7**: 447–451.

Smith, D. (1972) Cutting schedules and maintaining pure stands. In *Alfalfa Science and Technology* (C.M. Manson, Ed.). American Society of Agronomy, Madison, Wisconsin, p. 481–496.

Watschke, T. L., R. E. Schmidt and R. E. Blaser (1970) Responses of some Kentucky bluegrasses to high temperature and nitrogen fertility. *Crop Science*, **10**: 372–376.

Westhafer, M. A., J. T. Law, Jr., and D. T. Duff (1982) Carbohydrate quantification and relationships with N nutrition in cool-season turfgrasses. *Agronomy Journal*, **74**: 270–274.

White, L. M. (1973) Carbohydrate reserves of grasses: A review. *Journal of Range Management*, **26**: 13–17.

Wilkinson, J. F. and D. T. Duff (1972) Effects of fall fertilization on cold resistance, color and growth of Kentucky bluegrass. *Agronomy Journal*, **64**: 345–348.

Young, S. (1988) Growth in a cold climate. *New Scientist*, 28 July 1988.

Younger, V. B. and F. J. Nudge (1968) Growth and carbohydrate storage of three *Poa pratensis* L. strains as influenced by temperature. *Agronomy Journal*, **8**: 455–457.

Younger, V. B. and F. J. Nudge (1976) Soil temperature, air temperature, and defoliation effects on growth and nonstructural carbohydrates of Kentucky bluegrass. *Agronomy Journal*, **68**: 257–260.

Zarrough, K.M. and C.J. Nelson (1980) Regrowth of genotypes of tall fescue differing in yield per tiller. *Crop Science*, **20**: 540–544.

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